

APPENDIX B

BORING LOGS BY SHANNON & WILSON

APPENDIX B

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APPENDIX B

BORING LOGS BY SHANNON & WILSON

B.1 GENERAL

The field exploration program for the Greenwood Subsurface Characterization Study included drilling and sampling 11 borings. The borings were advanced at selected locations throughout the Greenwood study area where subsurface information was limited. The approximate exploration locations are shown on the Exploration Location Map (Figure 3).

A Shannon & Wilson, Inc. representative was present throughout the field exploration period to observe the drilling and sampling operations, retrieve representative soil samples for subsequent laboratory testing, and to prepare descriptive field logs of the explorations. Soils were classified in general accordance with the American Society for Testing and Materials (ASTM)

Designation: D 2488 Standard Recommended Practice for Description of Soils (Visual-Manual Procedure). The exploration logs presented in Figures B-2 through B-12 represent our interpretation of the subsurface conditions at each boring location based on our observations and the results of geotechnical laboratory testing. Figure B-1 presents a key to our classification of the materials encountered.

B.2 DRILLING

Borings GB-1 through GB-8 were completed by Geo-Tech Explorations of Kent, Washington, under subcontract to Shannon & Wilson, Inc., between December 1 and 23, 2003, using either a Mobile B-59 or B-61 truck-mounted CME-85 drill rig. Drilling was accomplished using hollow-stem auger and mud rotary techniques. The borings were advanced to depths ranging from about 9 to 61 feet.

The hollow-stem auger borings were drilled using a 4¼-inch inside-diameter continuous flight auger. Samples were retrieved from within the hollow-stem. Hollow-stem auger drilling was performed on borings GB-1, GB-3, GB-5, GB-6, and GB-8.

The mud rotary borings were advanced by circulating drilling mud from the drill rig down through 2⅝-inch outside-diameter NX rods to a 5⅞-inch-diameter tri-cone bit at the bottom of the borehole. The drilling mud is a mixture of bentonite powder and water. Cuttings are transported from the bottom of the borehole to the surface by drilling mud flowing between the

drilling rods and the sides of the borehole. The cuttings are deposited in a settling tank at the ground surface and the mud is recirculated. Mud rotary techniques were used on borings GB-2, GB-4, and GB-7.

Holt Drilling of Puyallup, Washington, under subcontract to Shannon & Wilson, Inc. drilled borings MW-1, MW-2, and TH-1 on January 14, 2004, using a Mobile B-59 truck-mounted drill rig. Drilling was accomplished using hollow-stem auger drilling methods. Borings MW-1 and MW-2 were advanced using a 4-inch inside-diameter continuous flight auger. Boring TH-1 was drilled using a 8¼-inch inside-diameter continuous flight auger.

B.3 SOIL TESTING AND SAMPLING

Disturbed soil samples were obtained from the borings in conjunction with performance of Standard Penetration Tests (SPTs). SPTs were performed in general accordance with ASTM Designation D 1586, Standard Method for Penetration Testing and Split-Barrel Sampling of Soils. SPTs were generally performed every 2.5 feet down to 15 to 25 feet and then at 5-foot intervals to the bottom of the boring. The SPT consists of driving a 2-inch, outside-diameter, split-spoon sampler a distance of 18 inches into the bottom of the borehole with a 140-pound hammer falling 30 inches. The number of blows required for the last 12 inches of penetration is termed the Standard Penetration Resistance (N-value). This value is an empirical parameter that provides a means for evaluating the relative density, or compactness, of granular soils and the consistency, or stiffness, of cohesive soils. These values are plotted at the appropriate depths on the boring logs included in this appendix. Generally, whenever 50 or more blows were required to cause 6 inches or less of penetration, the test was terminated, and the number of blows and the corresponding penetration was recorded. The N-values are plotted on the boring logs presented on Figures B-2 through B-9.

Relatively undisturbed samples were obtained of peat and cohesive soil in some borings by pushing a 3-inch-diameter, thin-wall tube into the bottom of the borehole.

Boring profiles between samples were interpreted based on cuttings and drill action.

B.4 MONITORING WELL INSTALLATION

Monitoring wells were installed in each of the borings to evaluate groundwater conditions. The monitoring wells were constructed of threaded, flush-jointed, 2-inch-diameter schedule 40 polyvinyl chloride (PVC). Well screen consisted of 2-inch-diameter, PVC pipe with

0.01-inch-wide, machine-slotted screen. A silica sand filter pack was poured in the annular space between the boring and the well screen to about 2 to 3 feet above the screen. Where the well screen is not at the bottom of the boring, the boring was filled with bentonite grout to the desired bottom of filter pack elevation before installing the pipe and filter pack. A minimum 2-foot-thick bentonite seal was placed in the annulus above the filter pack to within 3 feet of the surface. The wells were completed flush with the elevation of the surrounding grade by placing a flush-mount steel monument over the top of the borehole. The steel monuments were set in place with quick-set concrete.

B.5 VIBRATING WIRE PIEZOMETER (VWP) INSTALLATION

VWPs were installed in borings GB-2, GB-5, GB-7, and GB-8 in general accordance with the manufacturer's recommendations. A silica sand filter pack was installed between the VWP and the borehole wall. A minimum 2-foot-thick bentonite seal was placed directly above the filter pack. Details of the installations are indicated on the boring logs.

B.6 WELL DEVELOPMENT

All wells were developed to improve the hydraulic connection between the aquifer and the screened portion of the monitoring well. The development procedure consisted of a combination of surging and pumping. The saturated screened section of each monitoring well was surged and pumped simultaneously to remove water, drilling mud, and sediment from the bottom of the well. Development equipment consisted of a WaterraTM 2-inch-diameter, Acetal surge block/check-valve combination attached to the bottom of a dedicated section of semi-rigid high-density polyethylene (HDPE) tubing, operated by an electric WaterraTM motor. The sediment load of the purged groundwater was measured periodically by filling a container and observing the amount of sediment that settled out. Wells were pumped until there was no further observed improvement in water quality. About 35 to 55 gallons were evacuated from each of the wells.

B.7 REFERENCE

American Society for Testing and Materials (ASTM), 2003, Annual book of ASTM standards: Soil and rock, building stone; geosynthetics: Philadelphia, Pa., American Society for Testing and Materials, v. 04.08.

Shannon & Wilson, Inc. (S&W), uses a soil classification system modified from the Unified Soil Classification System (USCS). Elements of the USCS and other definitions are provided on this and the following page. Soil descriptions are based on visual-manual procedures (ASTM D 2488-93) unless otherwise noted.

S&W CLASSIFICATION OF SOIL CONSTITUENTS

- MAJOR constituents compose more than 50 percent, by weight, of the soil. Major constituents are capitalized (i.e., SAND).
- Minor constituents compose 12 to 50 percent of the soil and precede the major constituents (i.e., silty SAND). Minor constituents preceded by "slightly" compose 5 to 12 percent of the soil (i.e., slightly silty SAND).
- Trace constituents compose 0 to 5 percent of the soil (i.e., slightly silty SAND, trace of gravel).

MOISTURE CONTENT DEFINITIONS

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, from below water table

ABBREVIATIONS

ATD	At Time of Drilling
Elev.	Elevation
ft	feet
FeO	Iron Oxide
MgO	Magnesium Oxide
HSA	Hollow Stem Auger
ID	Inside Diameter
in	inches
lbs	pounds
Mon.	Monument cover
N	Blows for last two 6-inch increments
NA	Not applicable or not available
NP	Non plastic
OD	Outside diameter
OVA	Organic vapor analyzer
PID	Photo-ionization detector
ppm	parts per million
PVC	Polyvinyl Chloride
SS	Split spoon sampler
SPT	Standard penetration test
USC	Unified soil classification
WLI	Water level indicator

GRAIN SIZE DEFINITION











DESCRIPTION	SIEVE NUMBER AND/OR SIZE
FINES	< #200 (0.08 mm)
SAND* - Fine - Medium - Coarse	#200 to #40 (0.08 to 0.4 mm) #40 to #10 (0.4 to 2 mm) #10 to #4 (2 to 5 mm)
GRAVEL* - Fine - Coarse	#4 to 3/4 inch (5 to 19 mm) 3/4 to 3 inches (19 to 76 mm)
COBBLES	3 to 12 inches (76 to 305 mm)
BOULDERS	> 12 inches (305 mm)

* Unless otherwise noted, sand and gravel, when present, range from fine to coarse in grain size.

RELATIVE DENSITY / CONSISTENCY

COARSE-GRAINED SOILS		FINE-GRAINED SOILS	
N, SPT, BLOWS/FT.	RELATIVE DENSITY	N, SPT, BLOWS/FT.	RELATIVE CONSISTENCY
0 - 4	Very loose	Under 2	Very soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium dense	4 - 8	Medium stiff
30 - 50	Dense	8 - 15	Stiff
Over 50	Very dense	15 - 30	Very stiff
		Over 30	Hard

WELL AND OTHER SYMBOLS

	Bent. Cement Grout		Surface Cement Seal
	Bentonite Grout		Asphalt or Cap
	Bentonite Chips		Slough
	Silica Sand		Bedrock
	PVC Screen		
	Vibrating Wire		

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Greenwood Subsurface Characterization Study
Seattle, Washington

SOIL CLASSIFICATION AND LOG KEY

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FIG. B-1
Sheet 1 of 2

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) (From ASTM D 2487-98 & 2488-93)					
MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL		TYPICAL DESCRIPTION
COARSE-GRAINED SOILS (more than 50% retained on No. 200 sieve)	Gravels (more than 50% of coarse fraction retained on No. 4 sieve)	Clean Gravels (less than 5% fines)	GW		Well-graded gravels, gravels, gravel/sand mixtures, little or no fines
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines
		Gravels with Fines (more than 12% fines)	GM		Silty gravels, gravel-sand-silt mixtures
			GC		Clayey gravels, gravel-sand-clay mixtures
	Sands (50% or more of coarse fraction passes the No. 4 sieve)	Clean Sands (less than 5% fines)	SW		Well-graded sands, gravelly sands, little or no fines
			SP		Poorly graded sand, gravelly sands, little or no fines
		Sands with Fines (more than 12% fines)	SM		Silty sands, sand-silt mixtures
			SC		Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (50% or more passes the No. 200 sieve)	Silts and Clays (liquid limit less than 50)	Inorganic	ML		Inorganic silts of low to medium plasticity, rock flour, sandy silts, gravelly silts, or clayey silts with slight plasticity
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		Organic	OL		Organic silts and organic silty clays of low plasticity
	Silts and Clays (liquid limit 50 or more)	Inorganic	MH		Inorganic silts, micaceous or diatomaceous fine sands or silty soils, elastic silt
			CH		Inorganic clays or medium to high plasticity, sandy fat clay, or gravelly fat clay
		Organic	OH		Organic clays of medium to high plasticity, organic silts
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT		Peat, humus, swamp soils with high organic content (see ASTM D 4427)

NOTES

- Dual symbols (symbols separated by a hyphen, i.e., SP-SM, slightly silty fine SAND) are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.
- Borderline symbols (symbols separated by a slash, i.e., CL/ML, silty CLAY/clayey SILT; GW/SW, sandy GRAVEL/gravelly SAND) indicate that the soil may fall into one of two possible basic groups.

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SOIL CLASSIFICATION AND LOG KEY

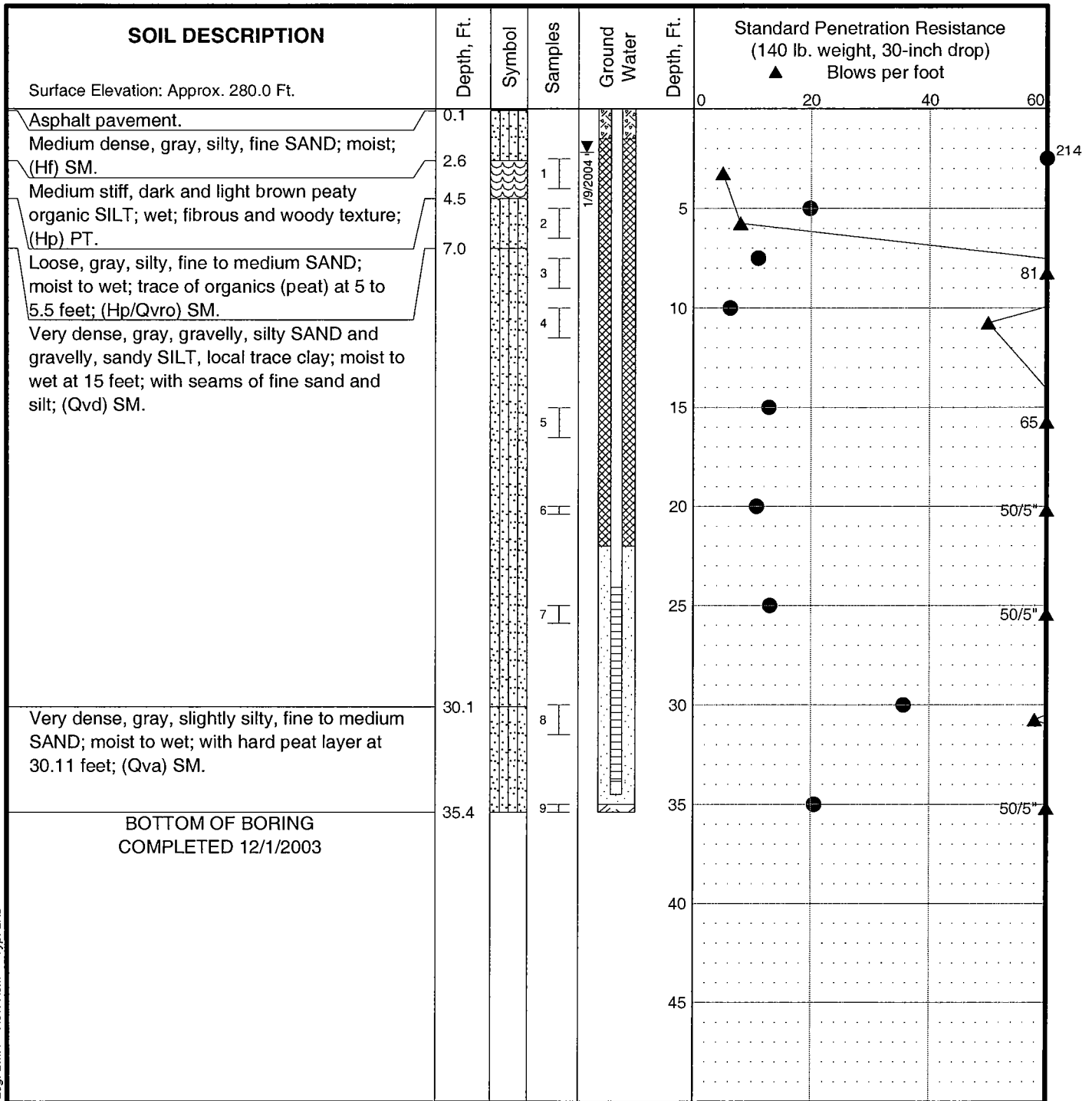
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FIG. B-1
Sheet 2 of 2

MASTER LOG2 21-09915.GPJ TEMP.GDT 4/21/04
 Log: BMR Rev: RJM Typ: LKD



- | | | |
|--|---|---|
| <p>* Sample Not Recovered</p> <p>Standard Penetration Test</p> | <p>LEGEND</p> <p>Piezometer Screen and Sand Filter</p> <p>Bentonite-Cement Grout</p> <p>Bentonite Chips/Pellets</p> <p>Bentonite Grout</p> <p>Ground Water Level in Well</p> | <p>● % Water Content</p> <p>Plastic Limit —●— Liquid Limit</p> <p>Natural Water Content</p> |
|--|---|---|

- NOTES**
- The boring was performed using hollow stem auger drilling methods.
 - The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
 - The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
 - Groundwater level, if indicated above, is for the date specified and may vary.
 - Refer to KEY for explanation of symbols, codes and definitions.
 - USCS designation is based on visual-manual classification and selected lab testing.

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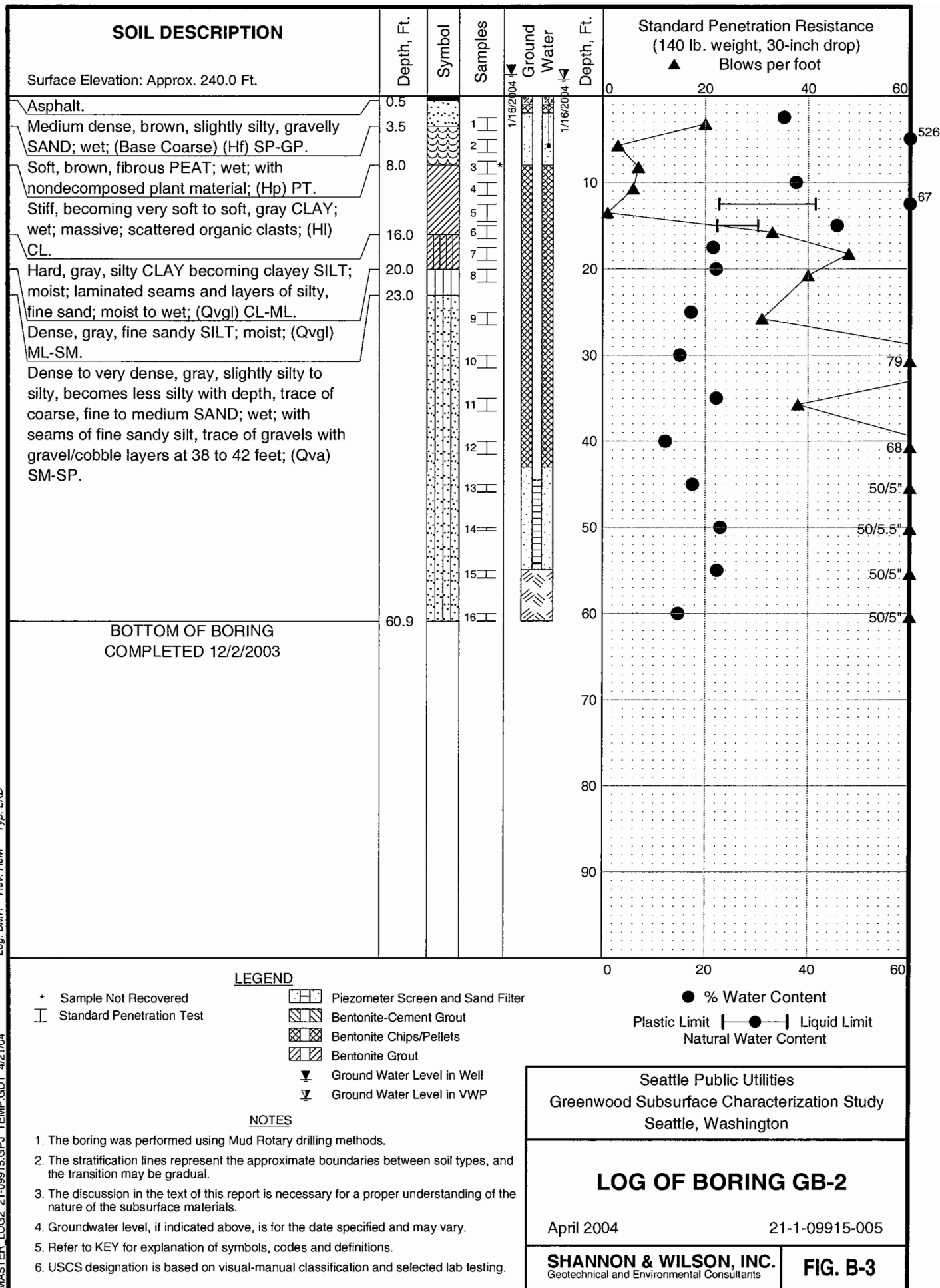
LOG OF BORING GB-1

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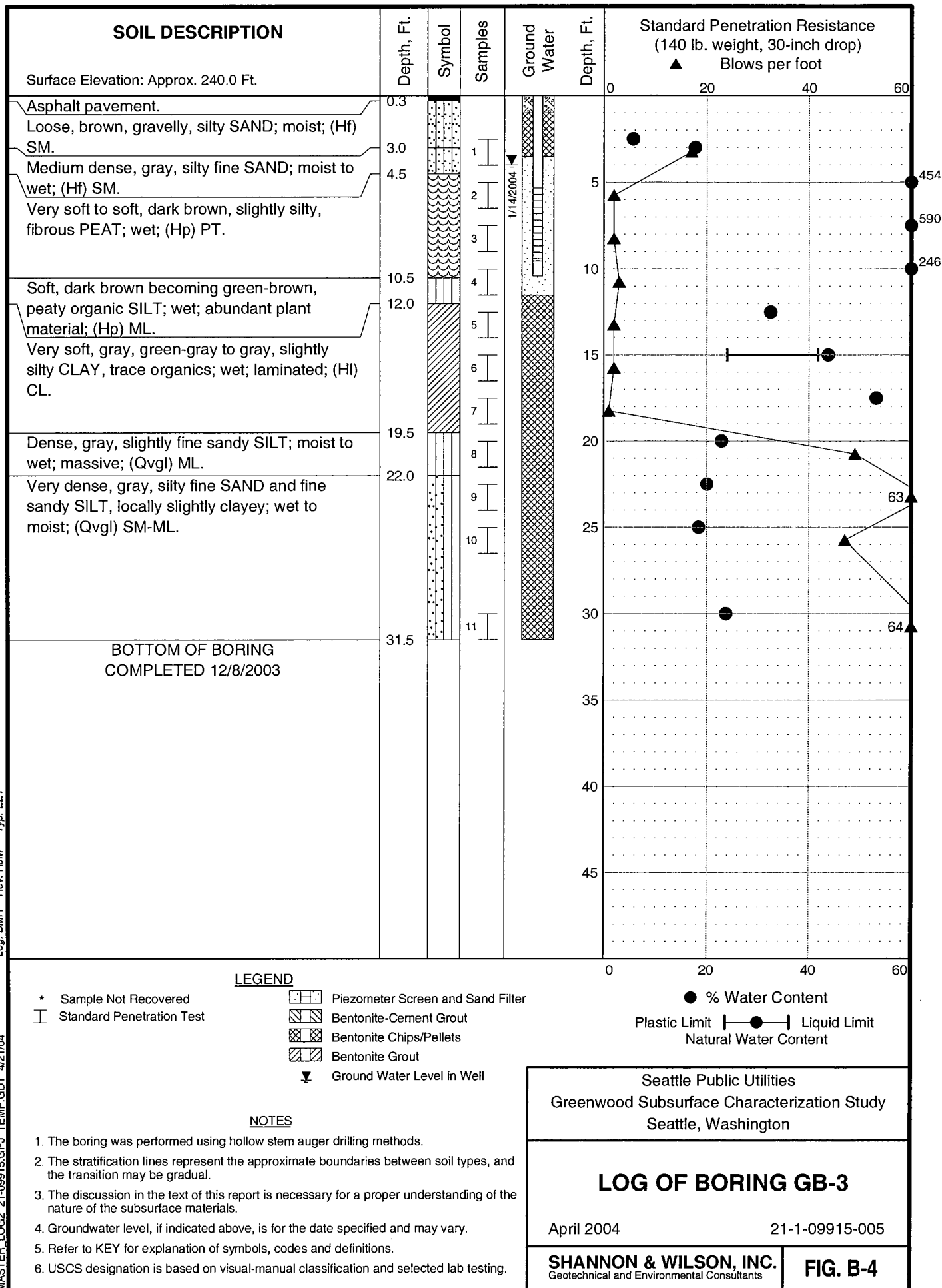
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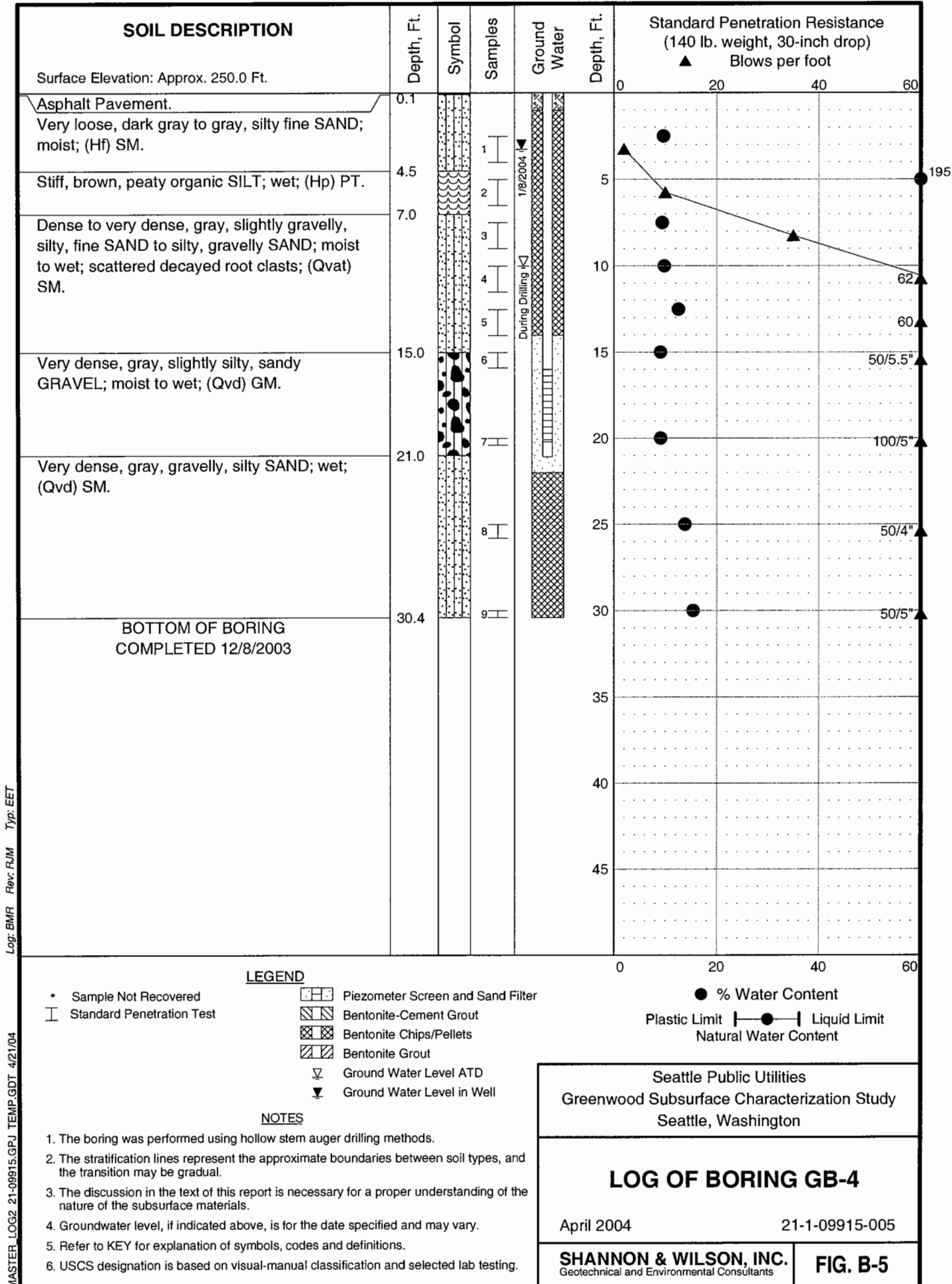
FIG. B-2



Log: BMR Rev: RJM Typ: EET

MASTER_LOG2 21-09915.GPJ TEMP.GDT 4/21/04



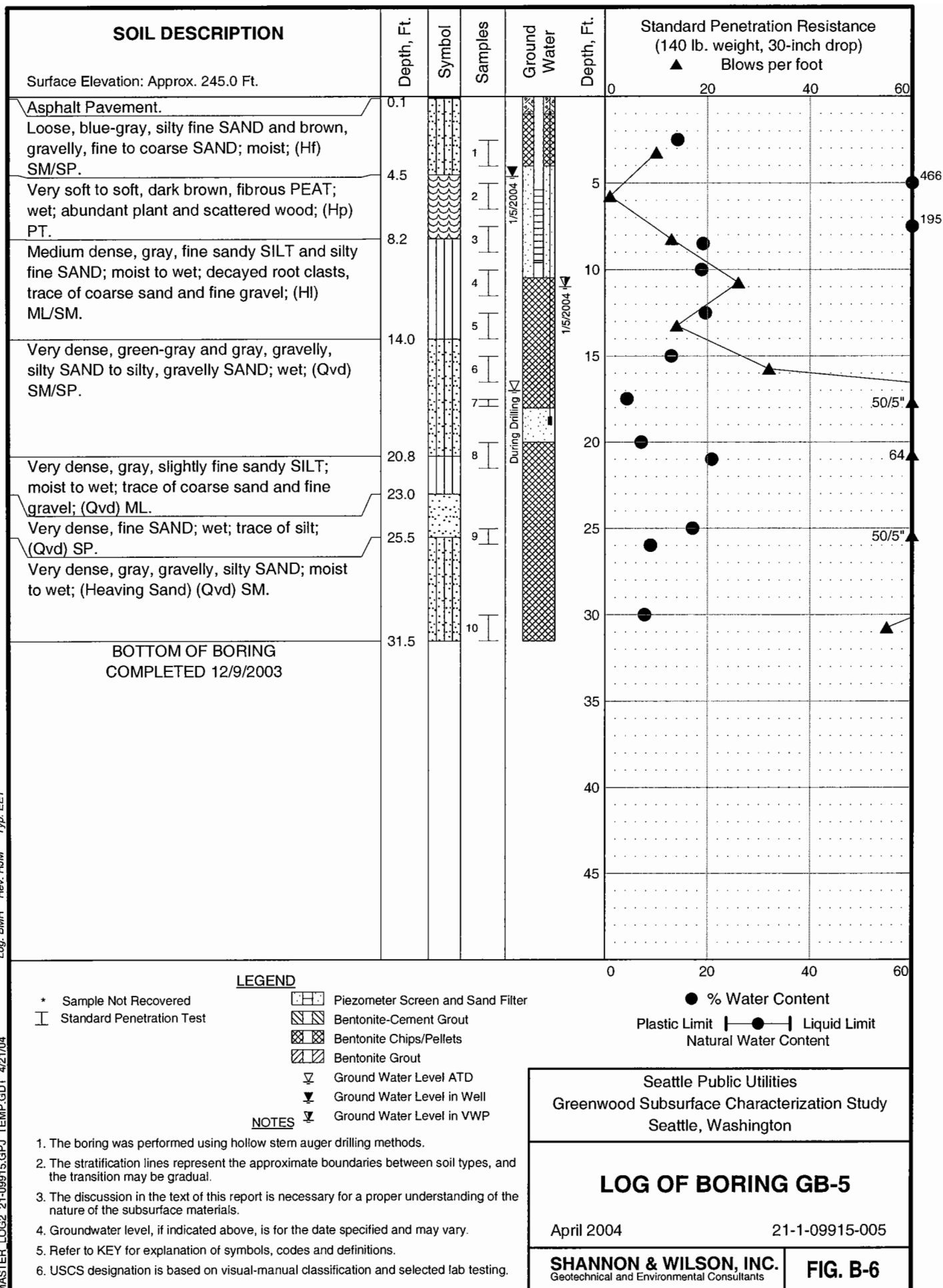


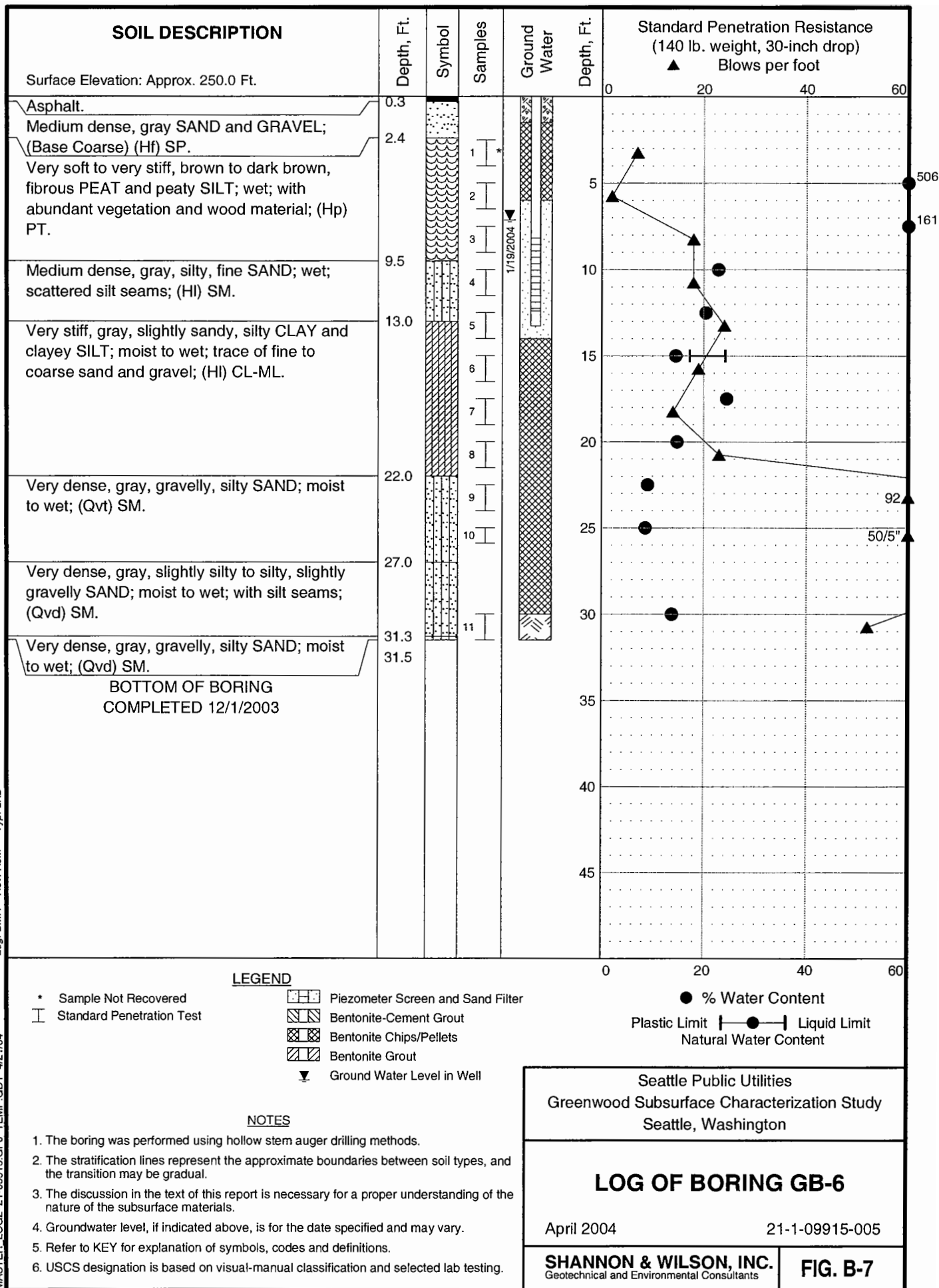
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MASTER_LOG 21-09915.GPJ TEMP.GDT 4/21/04

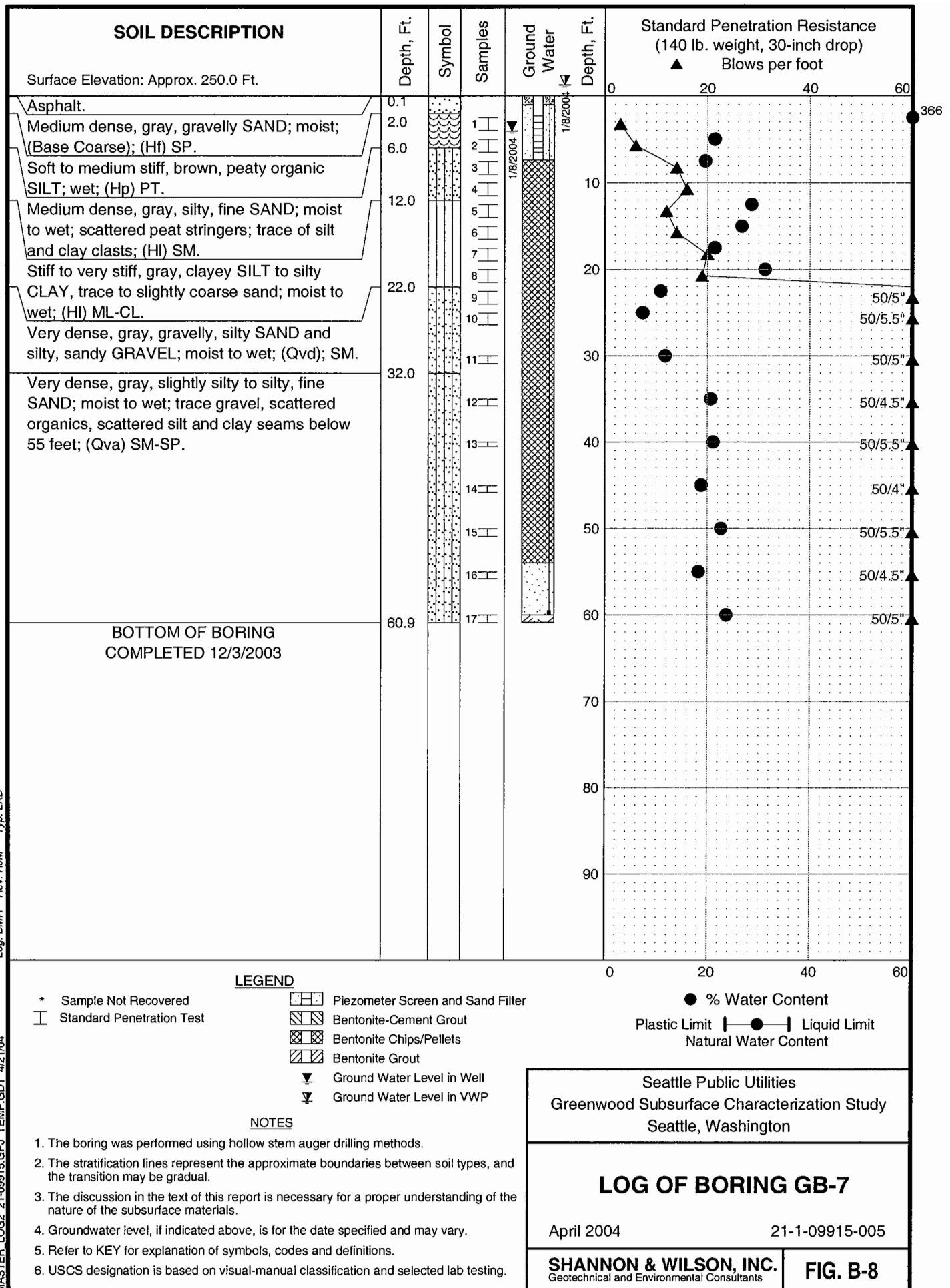
Log: BMR Rev: RJM Typ: EET

MASTER LOG2 21-09915.GPJ TEMP.GDT 4/21/04



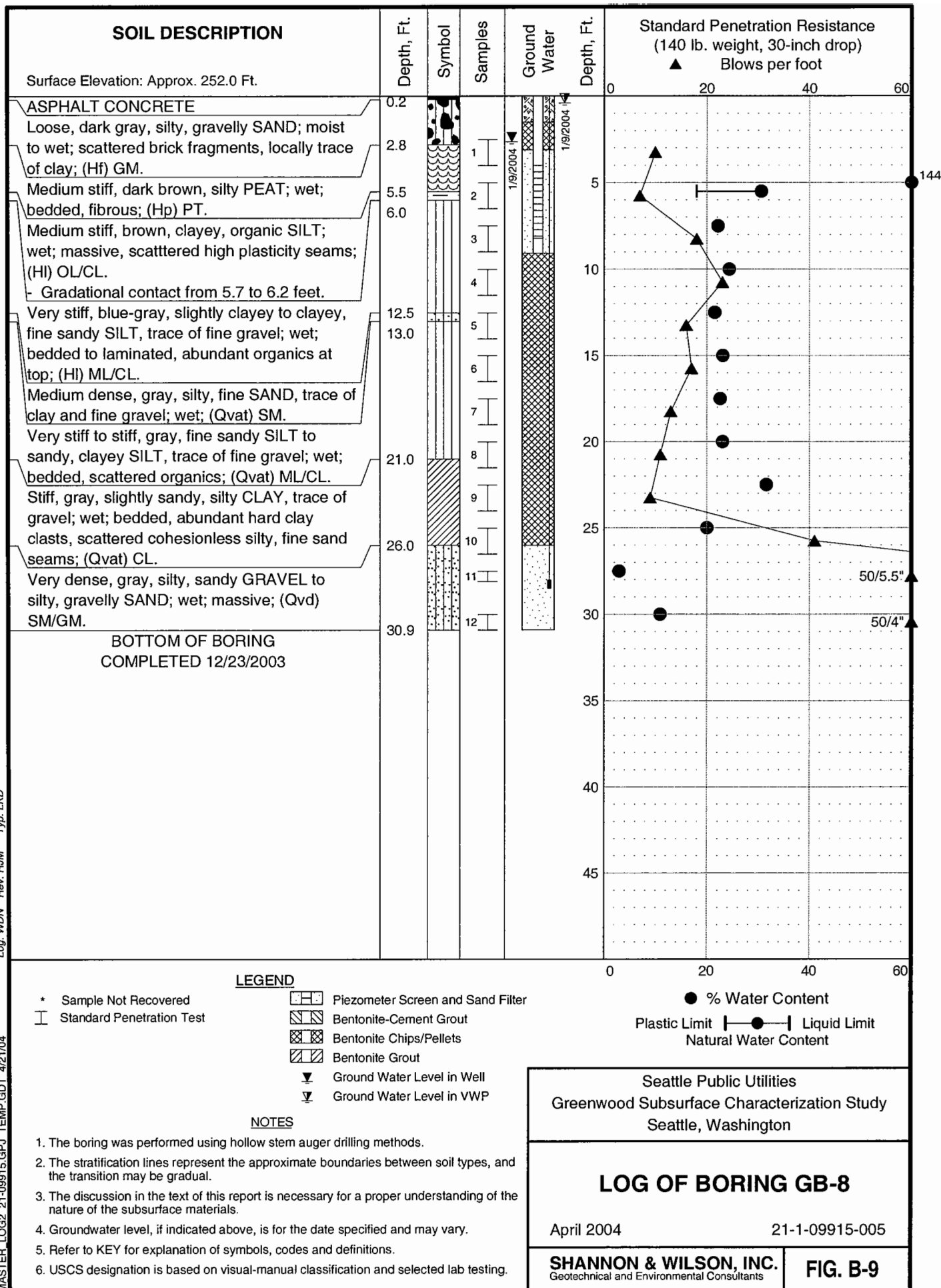


Log: BMR Rev: RJM Typ: LKD
MASTER_LOG2 21-09915.GPJ TEMP.GDT 4/21/04



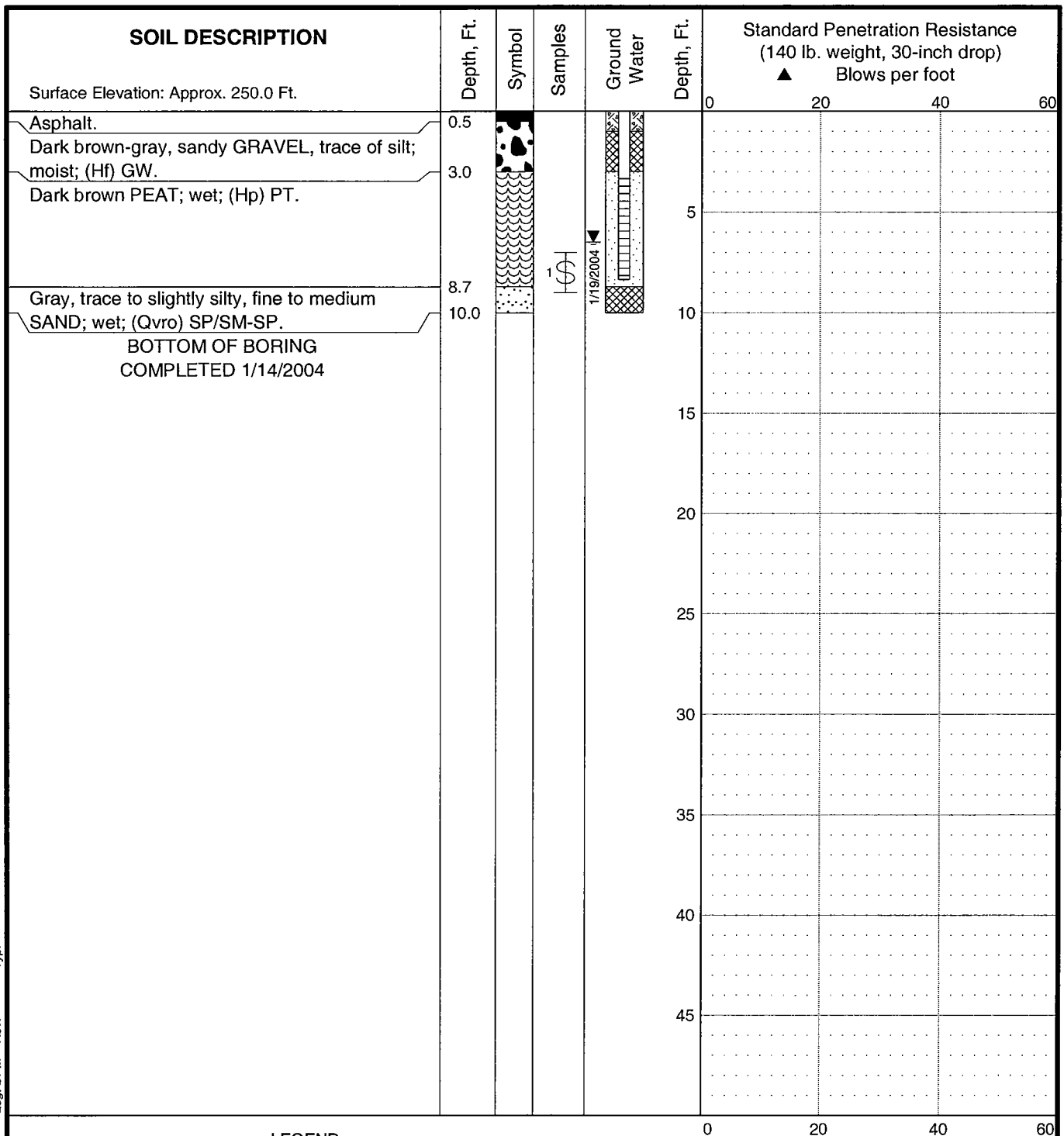
Log: WDN Rev: RJM Typ: LKD

MASTER LOG 21-09915.GPJ TEMP.GDT 4/21/04



Log: DPM Rev: Typ:

MASTER LOG2 21-09915.GPJ TEMP.GDT 4/21/04



LEGEND

- * Sample Not Recovered
- 3" O.D. Thin-Walled Tube
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level in Well

● % Water Content
Plastic Limit —●— Liquid Limit
Natural Water Content

NOTES

- The boring was performed using hollow stem auger drilling methods.
- The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
- The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
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Seattle, Washington

LOG OF BORING MW-1

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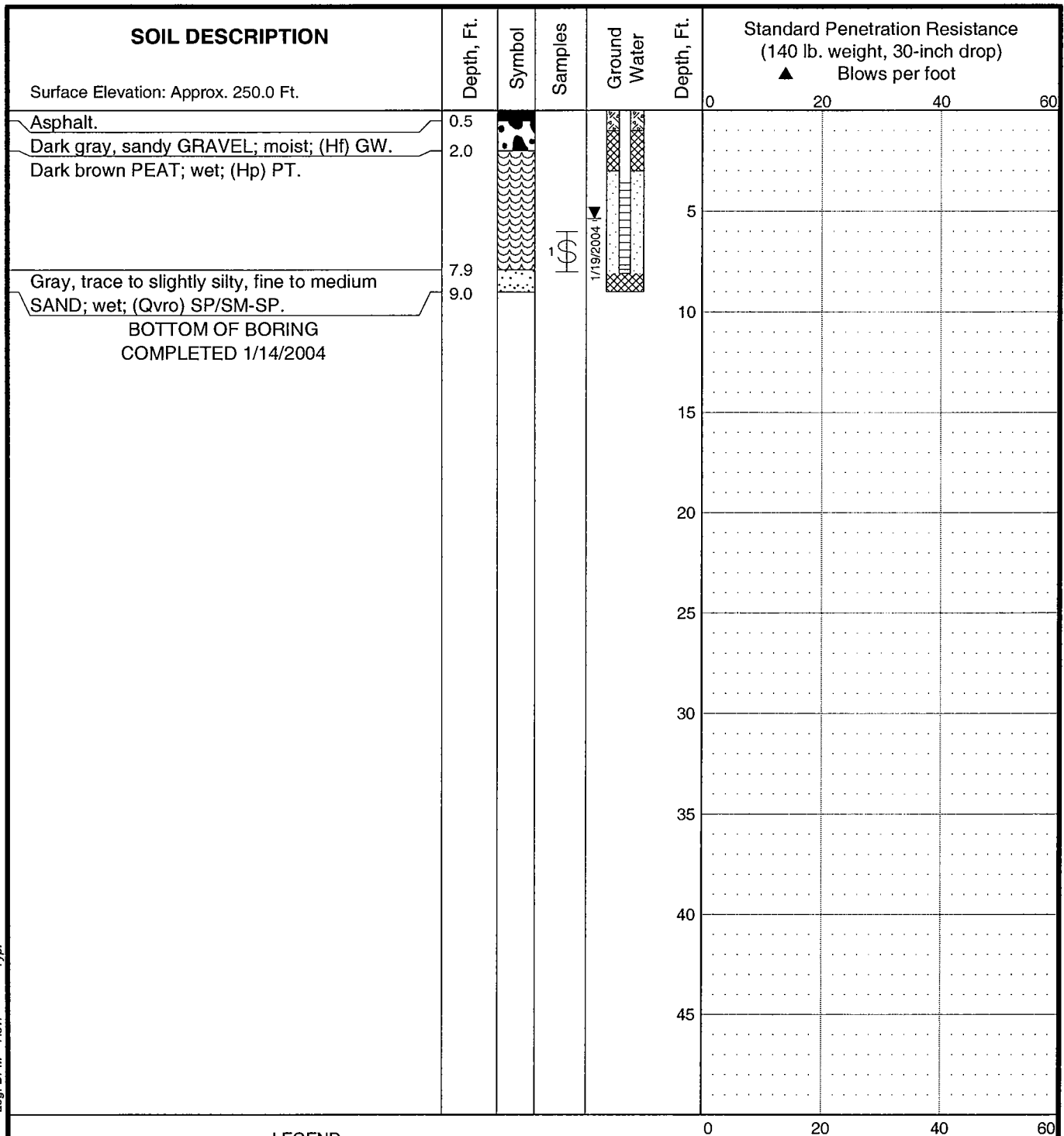
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FIG. B-10

Log: DPM Rev: Typ:

MASTER_LOG2 21-09915.GPJ TEMP.GDT 4/21/04



LEGEND

- * Sample Not Recovered
- 3" O.D. Thin-Walled Tube

- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level in Well

- % Water Content
- Plastic Limit
- Liquid Limit
- Natural Water Content

NOTES

- The boring was performed using hollow stem auger drilling methods.
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- The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
- Groundwater level, if indicated above, is for the date specified and may vary.
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LOG OF BORING MW-2

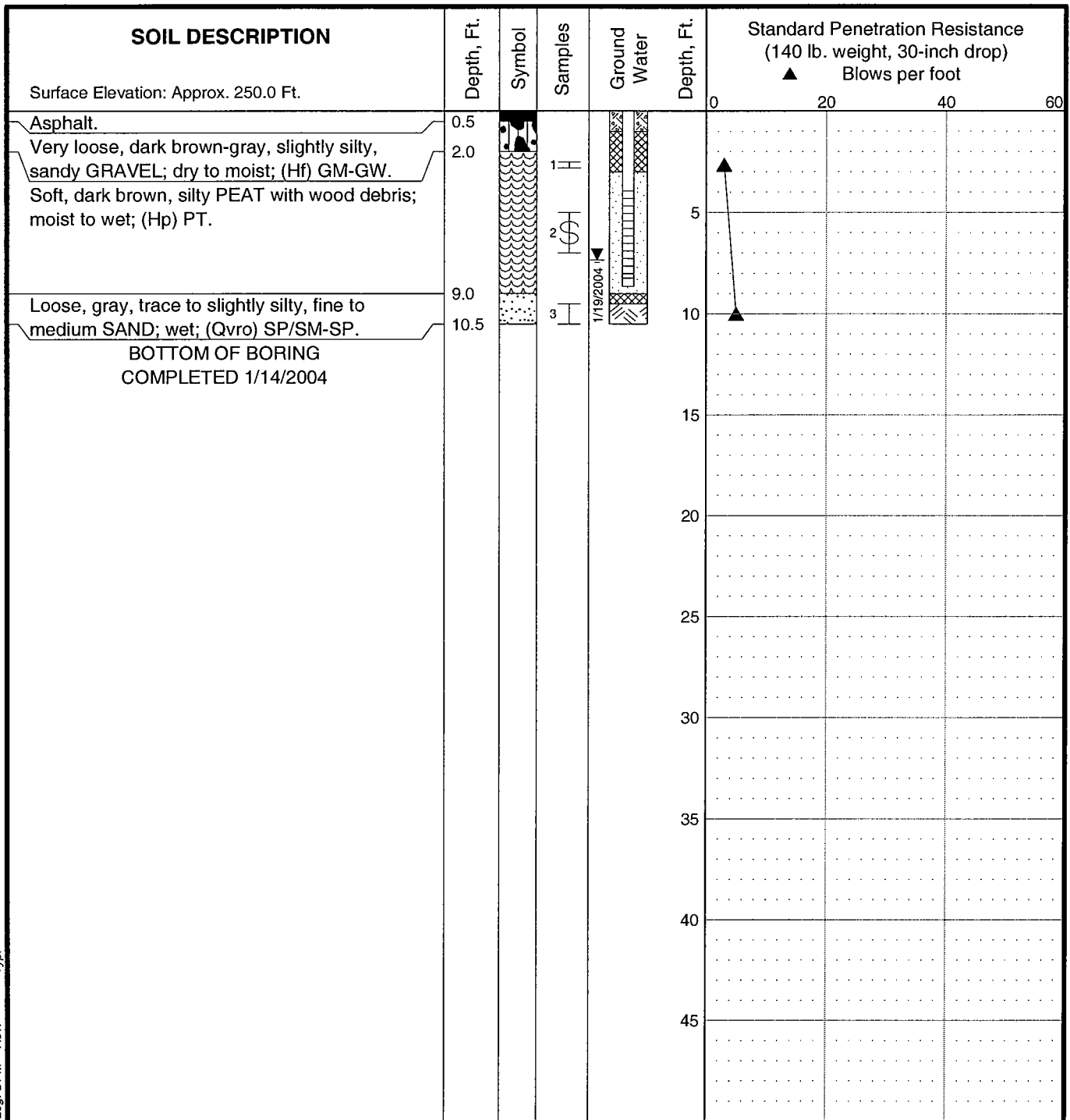
April 2004

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FIG. B-11

MASTER LOG2 21-09915.GPJ TEMP.GDT 4/21/04 Log: DPM Rev: Typ:



- | | | |
|--|--|---|
| <p>LEGEND</p> <ul style="list-style-type: none"> * Sample Not Recovered Standard Penetration Test 3" O.D. Thin-Walled Tube | <ul style="list-style-type: none"> Piezometer Screen and Sand Filter Bentonite-Cement Grout Bentonite Chips/Pellets Bentonite Grout Ground Water Level in Well | <ul style="list-style-type: none"> ● % Water Content —●— Liquid Limit —●— Plastic Limit —●— Natural Water Content |
|--|--|---|

- NOTES**
1. The boring was performed using hollow stem auger drilling methods.
 2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
 3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
 4. Groundwater level, if indicated above, is for the date specified and may vary.
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<h2 style="margin: 0;">LOG OF BORING TH-1</h2>	
April 2004	21-1-09915-005
SHANNON & WILSON, INC. Geotechnical and Environmental Consultants	FIG. B-12